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**PCT**NOTIFICATION CONCERNING  
SUBMISSION OR TRANSMITTAL  
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

Date of mailing (day/month/year) 11 April 2006 (11.04.2006)	<b>IMPORTANT NOTIFICATION</b>  International filing date (day/month/year) 28 December 2005 (28.12.2005)  Priority date (day/month/year) 02 February 2005 (02.02.2005)
Applicant's or agent's file reference 210_794PCT	
International application No. PCT/US2005/047362	
International publication date (day/month/year) Not yet published	
Applicant CARRIER CORPORATION et al	

1. By means of this Form, which replaces any previously issued notification concerning submission or transmittal of priority documents, the applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to a date of receipt, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. (If applicable) The letters "NR" appearing in the right-hand column denote a priority document which, on the date of mailing of this Form, had not yet been received by the International Bureau under Rule 17.1(a) or (b). Where, under Rule 17.1(a), the priority document must be submitted by the applicant to the receiving Office or the International Bureau, but the applicant fails to submit the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

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Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
02 February 2005 (02.02.2005)	60/649,268	US	24 February 2006 (24.02.2006)

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# Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/US2005/047362

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# THE UNITED STATES OF AMERICA

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United States Patent and Trademark Office

*February 16, 2006*

**THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.**

**APPLICATION NUMBER: 60/649,268**

**FILING DATE: *February 02, 2005***

**RELATED PCT APPLICATION NUMBER: *PCT/US05/47362***

**THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US60/649,268***



Certified by

*Don W. Dudas*

Under Secretary of Commerce  
for Intellectual Property  
and Director of the United States  
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**This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).**

**Express Mail Label No. EV434566365US**

INVENTOR(S)		Residence	
Given Name (first and middle [if any])	Family Name or Surname	(City and either State or Foreign Country)	
Mikhail B.	Gorbounov	South Windsor, CT	
Joseph J.	Sangiovanni	West Suffield, CT	
Additional inventors are being named on the <u>second</u> <u>separately numbered sheets attached hereto</u>			
<b>TITLE OF THE INVENTION (500 characters max)</b>			
<b>MINI-CHANNEL HEAT EXCHANGER WITH MULTI-STAGE EXPANSION DEVICE</b>			
Direct all correspondence to:		<b>CORRESPONDENCE ADDRESS</b>	
<input checked="" type="checkbox"/> Customer Number		20874	
OR		Type Customer Number here	
<input type="checkbox"/> Firm or Individual Name			
Address			
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City	State	ZIP	
Country	Telephone	315-425-9000	Fax 315-425-9114
<b>ENCLOSED APPLICATION PARTS (check all that apply)</b>			
<input checked="" type="checkbox"/> Specification Number of Pages	3	<input type="checkbox"/> CD(s), Number	
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets	4	<input checked="" type="checkbox"/> Other (specify)	
<input checked="" type="checkbox"/> Application Data Sheet. See 37 CFR 1.76		<b>Return Mail Room Postcard.</b>	
<b>METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT</b>			
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.		FILING FEE - AMOUNT (\$)200.00	
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees			
<input checked="" type="checkbox"/> The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 03-0835.			
<input type="checkbox"/> Payment by credit card. Form PTO-2038 is attached.			
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.			
<input checked="" type="checkbox"/> No.			
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____			

**SIGNATURE**

2) Date February 2, 2005

TYPED or PRINTED NAME Dana F. Bigelow

REGISTRATION NO. 26,441  
(if appropriate)

**Docket Number: 210 794PRO**

**TELEPHONE 315-425-9000**

**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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113009 U.S. PTO  
60/649268



**PROVISIONAL APPLICATION COVER SHEET**  
**Additional Page**

PTO/SB/16 (08-03)  
Approved for use through 07/31/2006. OMB 0551-0032  
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE  
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Docket Number 210 794PRO		
<b>INVENTOR(S)/APPLICANT(S)</b>		
Given Name (first and middle (if any))	Family or Surname	Residence (City and either State or Foreign Country)
Igor B.	Valsman	West Hartford, CT

[Page 2 of 2]

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

Effective on 12/08/2004.  
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4810).

# **FEE TRANSMITTAL** **For FY 2005**

## **Complete if Known**

Application Number	Not Assigned
Filing Date	Concurrently Herewith
First Named Inventor	Mikhail B. Gorbounov et al.
Examiner Name	Not Assigned
Art Unit	Not Assigned
Attorney Docket No.	210_794PRO

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT \$200.00

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### **METHOD OF PAYMENT (check all that apply)**

☐ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify):

☒ Deposit Account Deposit Account Number: 03-0835 Deposit Account Name: Carrier Corporation

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

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☒ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17

☒ Credit any overpayments

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### **FEE CALCULATION**

#### **1. BASIC FILING, SEARCH, AND EXAMINATION FEES**

Application Type	FILING FEES		SEARCH FEES		EXAMINATION FEES		Fees Paid (\$)
	Fee (\$)	Small Entity Fee (\$)	Fee (\$)	Small Entity Fee (\$)	Fee (\$)	Small Entity Fee (\$)	
Utility	300	150	500	250	200	100	
Design	200	100	100	50	130	65	
Plant	200	100	300	150	160	80	
Reissue	300	150	500	250	600	300	
Provisional	200	100	0	0	0	0	200.00

#### **2. EXCESS CLAIM FEES**

Fee Description							Fee (\$)	Small Entity Fee (\$)
Each claim over 20 or, for Reissues, each claim over 20 and more than in the original patent							50	25
Each independent claim over 3 or, for Reissues, each independent claim more than in the original patent							200	100
Multiple dependent claims							360	180
Total Claims		Extra Claims		Fee (\$)		Fee Paid (\$)	Multiple Dependent Claims	
0	- 20 or HP =	0	x	0.00	=	0.00	Fee (\$)	
HP= highest paid number of total claims paid for, if greater than 20							Fee Paid (\$)	
Indep. Claims		Extra Claims		Fee (\$)		Fee Paid (\$)		
0	- 3 or HP =	0	x	0.00	=	0.00		
HP =highest number of independent claims paid for, if greater than 3								

#### **3. APPLICATION SIZE FEE**

If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a) (1)(G) and 37 CFR 1.16(s).

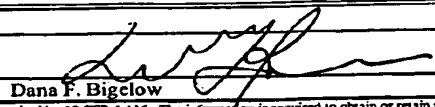
Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof	Fee (\$)	Fee Paid (\$)
7	- 100 = 0	/ 50 = (round up to a whole number)	x 0.00	= 0.00

#### **4. OTHER FEES**

Non-English Specification, \$130 fee (no small entity discount)

Other:

#### **SUBMITTED BY**

Signature		Registration No. 26,441 (Attorney/Agent)	Telephone 315-425-9000
Name (Print/Type)	Dana F. Bigelow		Date February 2, 2005

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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**Mini-Channel Heat Exchanger with Multi-Stage Expansion Device**

The non-uniform distribution of two-phase refrigerant in parallel tubes, for example in mini- or micro-channel heat exchangers (MCHX), can significantly reduce heat exchanger efficiency. This is called maldistribution and is a common problem in heat exchangers that utilize parallel refrigerant paths. Two-phase maldistribution problems are caused by the difference in density of the vapor and the liquid phases.

One way of significantly reducing maldistribution in a MCHX operating in the evaporator mode is to distribute the refrigerant in the single-phase liquid state in parallel paths prior to the actual expansion process. Then, the two-phase fluid will appear only in the MCHX tubes after distribution has already been accomplished.

In a MCHX, the flow of refrigerant is divided into many parallel tubes (circuits), where every tube and especially every mini-channel should receive just a small and equal fraction of the total refrigerant flow. The requirement to have a full expansion of liquid in one expansion device for each mini-channel or even one mini-channel tube leads to an unreasonably small orifice restriction, which is significantly smaller than a typical channel of a MCHX. Moreover, a very small orifice restriction is difficult to manufacture precisely and it is susceptible to internal clogging by foreign matter.

One way of overcoming these difficulties is to produce the desired refrigerant expansion process by flowing the refrigerant through multiple orifice restrictions arranged in series. Inasmuch as the pressure drop produced in a fluid flow by an orifice restriction is created as a result of momentum exchange in the fluid at the inlet and at the outlet of the orifice, the fluid pressure drop created by an orifice restriction is inversely proportional to the orifice size or dimension; larger orifice size produces less pressure drop. Therefore, multiple large orifice restrictions in series can be used to create the same fluid pressure drop as a single small orifice restriction. For the same overall fluid pressure drop or refrigerant expansion, the dimension or size of a multiple of orifices that are arranged in series are larger than the dimension of a single orifice.

Figures 1 and 2 show a mini-channel tube 1 inserted at one end of the restrictive connector 4 inserted into the header wall 3. The other end of the restrictive connector may include two or more expansion restrictions. Refrigerant in the single-

phase liquid state flows through the header 3, expands in consecutive restrictions 5, and enters the mini-channel tubes with multiple mini-channels in a two -phase state.

In Figures 3 and 4 another embodiment is shown. The mini-channel tube is inserted into the restrictive connector 4, which has a longer shape to prevent plugging of the restrictions during the brazing process and to provide additional support by having the restrictive connector rest on the inner surface of the header 3. Figure 4 shows the case of a round header.

One more embodiment is shown in Figures 5 and 6, where the end 6 of expansion restrictive connector 4 is closed. The first expansion is performed in one or many holes 7 in the wall of the connector into the first expansion chamber 8. Figure 6 shows the case of a rectangular header.

Figures 7 and 8 show another embodiment, where the restrictive connector is manufactured from extruded flat tube and the restrictions are created by profiled pressing rather than casting required for the other embodiments.

Most modern HVAC applications are designed for both cooling and heating (heat pump) modes of operation. In this case the same MCHX has to operate efficiently as an evaporator and as a condenser. The proposed method of solving maldistribution for the evaporator mode requires permanent deployment of the proposed restriction connector in the inlet header of a MCHX, so the expansion happens before the heat transfer process in the evaporator. When the same MCHX operates as a condenser, the refrigerant flow is reversed and the expansion process takes place after the heat transfer process. Now for the heat pump mode the same header is an exit for condensed refrigerant.

Typical operating conditions for cooling and heating need different refrigerant temperature, pressure and flow in the cycle, which lead to different flow conditions and pressure drop requirements for the expansion process. To satisfy both cooling and heating conditions with the same restrictive connector in the header of a MCHX the restrictions should be designed to provide different resistances for the two different flow directions.

For example, in the heating mode more refrigerant flow resistance might be required than for the cooling mode. Figure 9 shows one possible way of achieving more pressure drop for the evaporator in the heating mode than for the condenser in the cooling mode. For the heating mode the refrigerant flow is restricted by sharp edged



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PATENT

Attorney Docket No. 210\_794PRO (11150 R-5916)

orifices, while for the cooling mode the flow encounters lower resistance from smooth profile orifices E.

Multiple Expansion inside header at inlet to the  
tube - 1

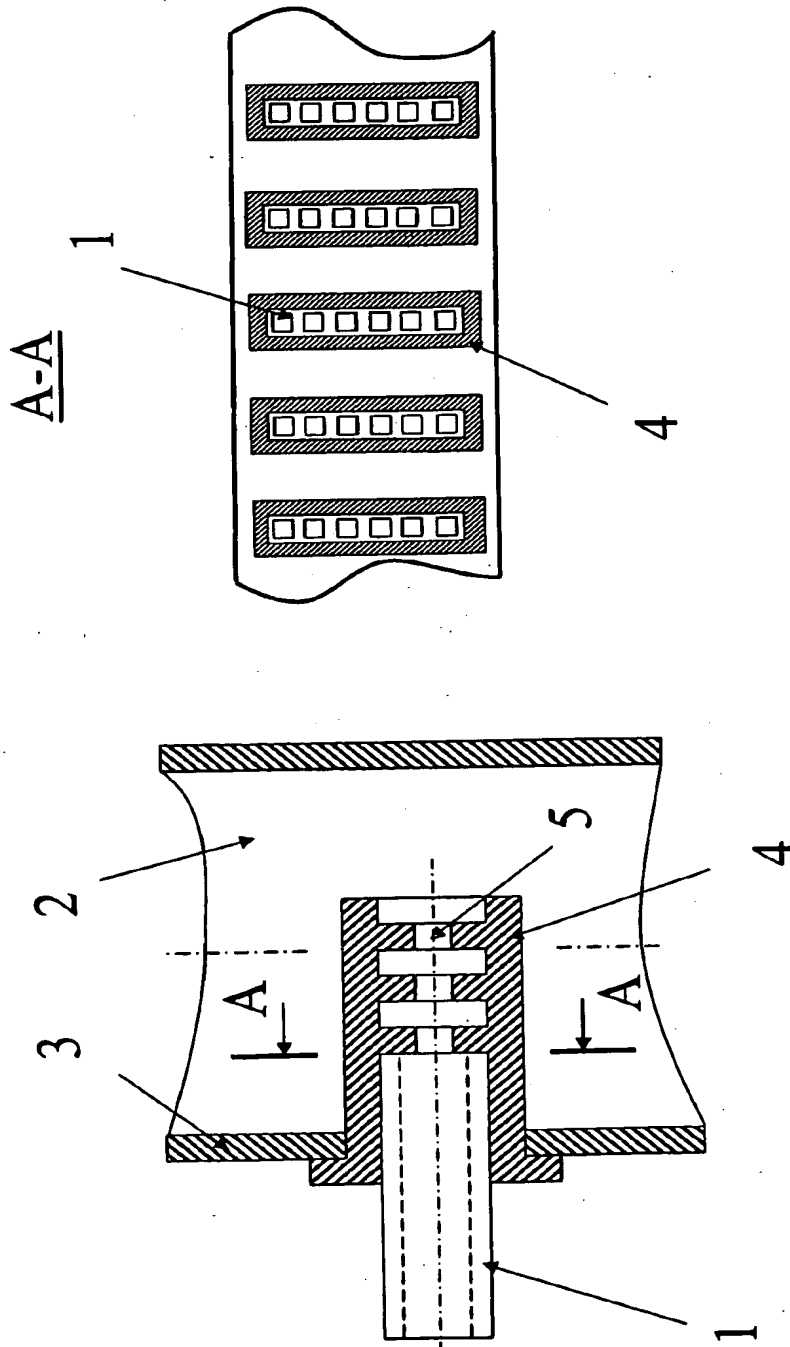


Fig 2

Fig 1

Multiple Expansion inside header at inlet to the  
tube - 2

B-B

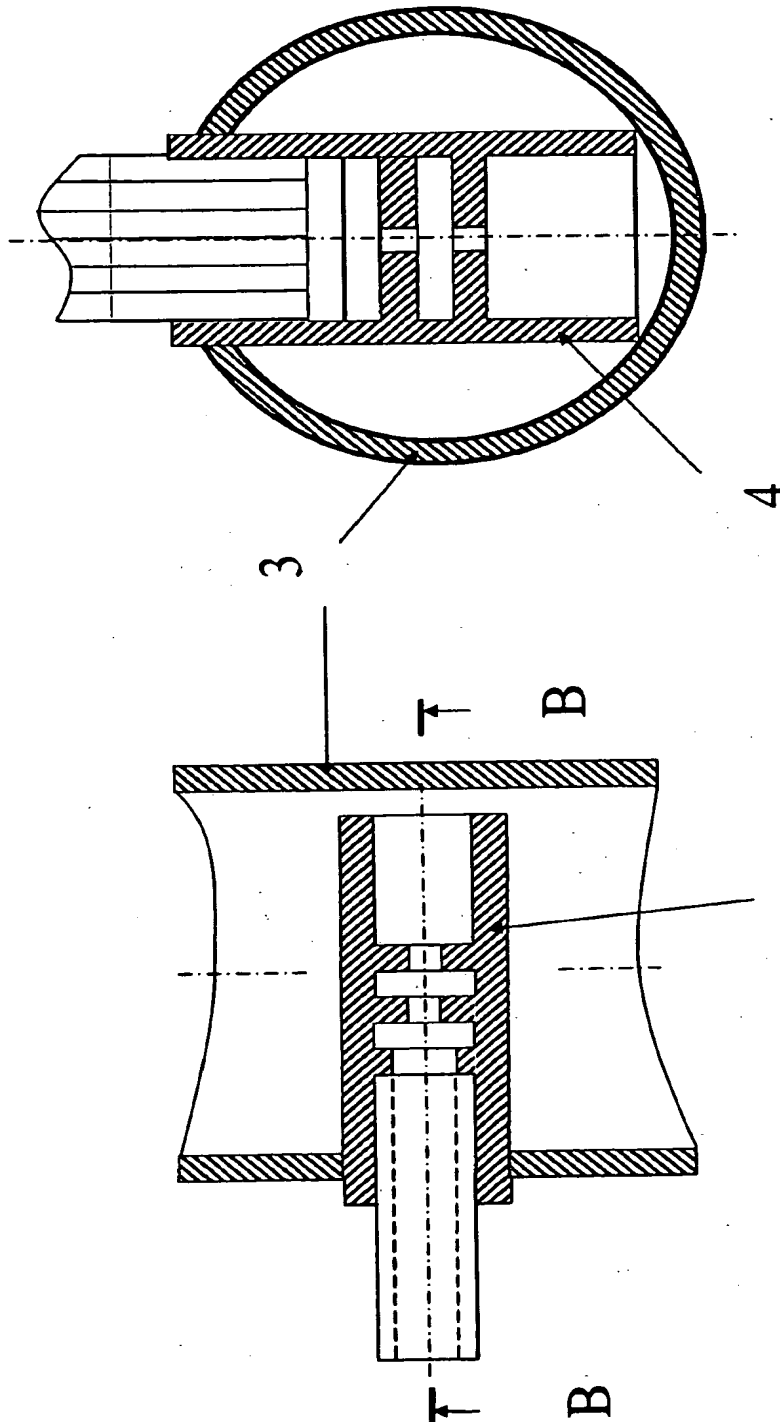


Fig 4

Fig 3

Multiple Expansion inside header at inlet to the  
tube - 3

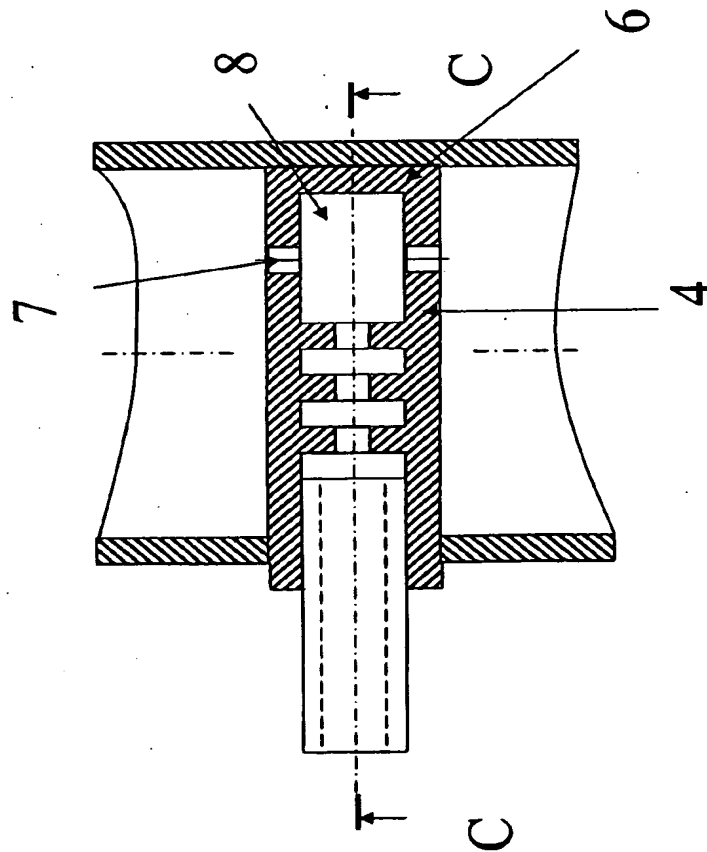


Fig 5

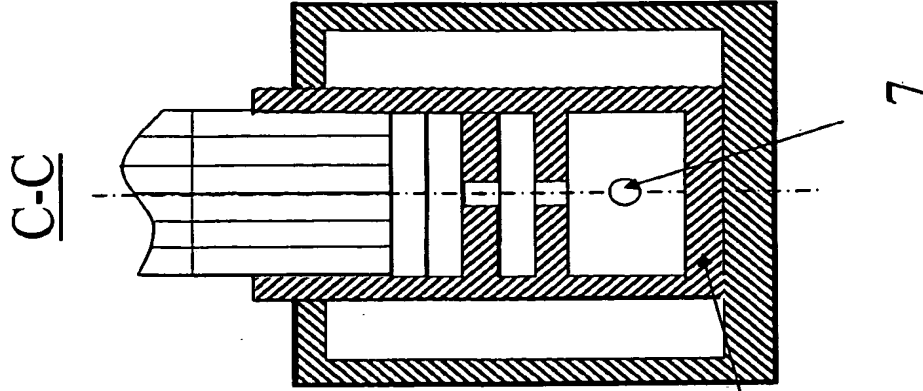


Fig 6

Multiple Expansion inside header at inlet to the tube -4

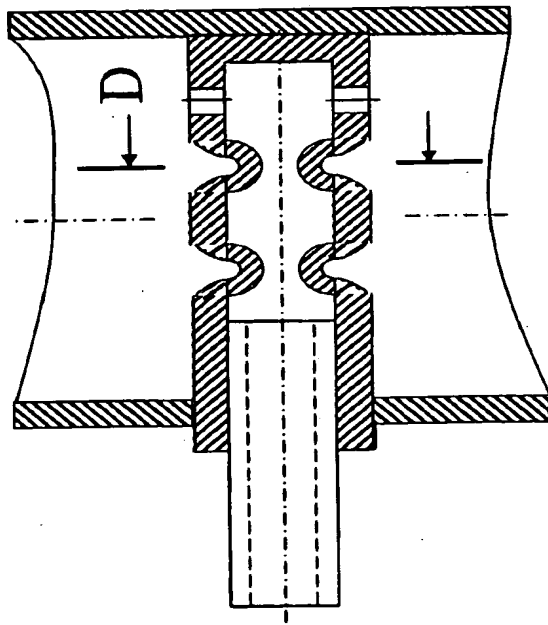


Fig 7

D-D

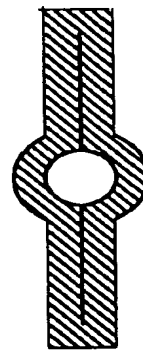


Fig 8

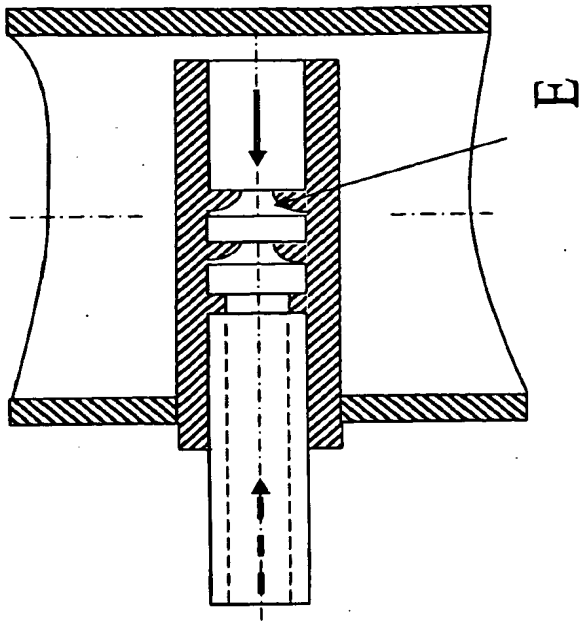


Fig 9

---> cooling  
 ---> heating